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AERIAL SURVEYS FOR RESERVOIR PLANNING

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AERIAL SURVEYS FOR RESERVOIR PLANNING

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SYNOPSIS

Engineers who plan and design multipurpose reservoir projects know that the importance of securing dependable topograpic maps cannot be overestimated. Topographic mapping of the extensive areas of such projects by transit and level or planetable and alidade are time-consuming and expensive. The speed, economy, and map accuracies obtained with photogrammetric methods now in use make it essential to give full consideration to utilizing aerial surveying for mapping reservoir projects for as many planning purposes as practicable.

INTRODUCTION

Preliminary planning for reservoir projects, namely: the selection of the dam sites, the determination of the drainage areas and reservoir levels, the computation of reservoir volumes, the calculation of backwater curves, and flood routing of past and possible future floods, usually can be satisfactorily accomplished, as it has been done for many years, by assembling a composite map or maps of uniform scales from all available topographic survey information and a limited amount of new field survey data. This generally has consisted of utilizing available quadrangle sheets prepared by Federal agencies, the scales of which have varied in the past from 1:125,000 with contour intervals of 100 feet to 1:24,000 with contour intervals of 10 to 40 feet, supplemented by the use of mosaics made from available aerial photographs and additional contour information secured where considered vitally needed by planetable surveys using the minimum of horizontal and vertical controls. The volume and accuracy of available maps have been greatly increased during the past 15 years by Federal agency programs of mapping and remapping quadrangles on a 1:24,000 scale from new aerial photographic data, and translating it by multiplex areoprojector into standard accuracy topographic maps.

Although the latest of these 1:24,000 scale Federal maps being produced are of high quality, neither is the scale large enough nor is the contour interval small enough for use in planning and designing all the engineering and related features of multipurpose reservoir projects preparatory to construction. After the site is fixed for the dam, which normally covers a relatively small area of the whole reservoir project, topography needed for the dam and its appurtenant works can be secured accurately, economically, and with dispatch by conventional transit and level survey methods. However, the topography needed for planning the related features, usually called reservoir planning, is

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much more extensive and varied. The time required to accomplish these surveys by conventional ground methods and to compile the various maps is so great and the cost is so enormous that much detail and topographic coverage is frequently sacrificed.

In 1951, after experiencing the problems and the high costs or surveying and mapping the reservoir areas of several projects of the Corps of Engineers in the South Atlantic Division to meet reservoir planning needs, it was decided to investigate the feasibility of using aerial surveys and stereoscopic mapping to effect economies and to expedite that phase of project planning. It was recognized that to accomplish these objectives the resulting maps must be made at some uniform scale or scales, using photographs of only one series of aerial survey flights.

The most suitable scale at which to map the reservoir area must be determined by fully considering the uses that are to be made of the completed maps. The following discussion of the several components of reservoir planning and of the scales of maps previously adopted and used for such planning will give an understanding of the factors involved in the choice of scales for aerial surveying and mapping of reservoir projects.

Land Acquisition

Planning for land acquisition for a reservoir project is a two-fold problem: one is the fixing of the boundary of the project or taking line, as required to operate it for the purposes for which it is authorized to be constructed; the other is that of mapping the various tracts of land for real estate appraisal and purchase either in fee title or easement estate. To resolve these problems careful consideration must be given to the terrain and to the location and elevation of natural and cultural features. The more accurate the basic topographic maps are, the simpler the task of planning and accomplishing the land acquisition.

The first step toward establishing the reservoir taking line is the hydrological determination of significant reservoir flood pool elevations below which the lands must be acquired. Depending entirely upon terrain characteristics, several feet are frequently added to these elevations to allow for anticipated shoreline erosion and changed watertable effects. These elevations, when plotted on a contoured map of the reservoir, are connected by lines that form a sloped contour that embraces the land to be covered by the water surface of the reservoir plus any land areas of the reservoir shore that are expected to be physically changed by the reservoir during adverse flood conditions. This sloped contour is the basic guide line for land acquisition and has been most effectively used for this purpose when incorporated on reservoir topographic maps of a scale of 1:6000 and on a controlled mosaic of a scale of 1:12,000. Once the guide line for acquisition has been established and mapped a tentative taking line is delineated that will satisfy the requirements of management and operation for project purposes and the administration of incidental permissible uses anticipated or planned for the reservoir.

When the tentative taking line is projected on the reservoir topographic maps and aerial mosaics, the lands traversed by this line are evident. Work on obtaining ownership information and preparing property maps of the boundary tracts may then proceed and complement similar work on tracts lying entirely within the reservoir taking line. These property maps, used for real estate appraisals and tract acquisitions, have been satisfactorily prepared by utilizing photographic prints of flight negatives and reproducible prints of topographic maps, with the prints of the flight negatives being enlarged to a

1:6000 scale and the topographic maps showing culture, grid and control network also on a 1:6000 scale. After all property corners are located and indicated on prints of the topographic map at the scale of 1:6000, the individual tract acreages and descriptions are determined therefrom. The tract boundaries are then delineated on the controlled mosaic scale 1:12,000. The final map required for land acquisition is a composite map traced from the aerial mosaic, showing the tracts, pertinent contours, grid system and tract numbers, and containing a register indicating the tract number, name of owner, and the estate acquired in the reservoir lands.

Relocations

There are few, if any, sites selected in the southeast United States for multipurpose dams where the reservoirs formed by their construction will not inundate a number of railroads, highways, or county roads that must be relocated to meet traffic requirements. Topography is frequently a determining factor in fixing the alignment of the longer relocations. Preliminary paper locations and ruling grades have been determined by using Federal quadrangle maps of the 1:24,000 scale; however, these have seldom been available for planning purposes in multipurpose reservoirs unless made specifically for them. Frequently the final alignment for either railroad or highway has been selected from topographic maps of 1:6000 and controlled mosaics of 1:12,000 with only a check by field reconnaissance. The time required and the costs encountered to run alternate preliminary lines by transit and level are thereby saved. These larger scale topographic maps are also used in the acquisition of right-of-way lands in similar manner as they are used for acquisition of the reservoir lands. Another, and important, use is made of the topographic maps to determine the drainage areas tributary to bridges and culverts on the relocated railways and highways.

Special Reservoir Studies

The deposition of silt in reservoirs carried in by tributary rivers and creeks is of special interest in the planning stage of a project since the storage capacity of the reservoir is gradually diminished by siltation. Continuing post-construction measurements are made of volume and rate of siltation, not only as a record of the changes in the reservoir but also to use as reference data in similar work elsewhere. The reservoir projects in the authorized program of the Corps of Engineers in the southeast have large storage volumes in comparison with the estimated rates of deposition. These reservoirs are not expected to be functionally impaired by siltation until long beyong their normal economic life spans. Silt ranges are selected in a reservoir, and cross sections are taken before impoundment for comparing with future cross sections taken along the same ranges at time intervals sufficient to record the changes in silt accumulations. Dependable topographic maps of scale 1:24,000, or greater, are especially useful in locating and selecting the smallest number of ranges that should be established to carry out the siltation studies.

River or stream bank erosion and channel changes which may take place below the dam as a result of water discharges during project operation are also a concern of the operating agency. Records of these changes are secured by comparing cross sections taken periodically after completion of construction with cross sections taken before the start of project operation and as indicated by study of aerial mosaics flown at low altitudes during or before project construction.

Reservoir Preparation

Although there are a number of reservoirs that have been filled without having been previously prepared for inundation by the cleanup of floatable debris and disposal of standing timber, there are valid reasons that fully justify some degree of cleanup and timber removal in most of the large multi-purpose reservoirs, particularly those constructed here in the South and Southeast.

In planning for the reservoir clearing, consideration is given to accomplishing those phases of clearing that are required for eliminating obstructions to navigation; mosquito control to protect resident population and visitors to the reservoir from malaria and other mosquito-borne diseases indigenous to the locality of the reservoir; preventing interference with operation of or damage to project structures from floating debris; permitting recreation, boating, fishing and other public uses; preserving scenic attractiveness and conserving fish and wildlife; and facilitating operational maintenance and post-impoundment siltation studies.

Until after the period of unlimited availability of cheap manpower and prior to the advent of the bulldozer rake and the portable power saw, the clearing of reservoirs was customarily performed by hand labor organized and hired at the site or by small acreage contracts with landowners and small local operators. Except for making preliminary estimates of time and costs required to perform the clearing there was little need for accurately mapping the work to be performed. Shortages of manpower and development of heavy construction equipment during the latter part of the 1930's and the early 1940's made it expedient to perform reservoir clearing by contract to private construction firms.

This step in accomplishing the clearing by construction contracts made it necessary to prepare representative plans, specifications, and estimates to portray the work involved. The reservoir topographic maps that had been prepared for preliminary planning purposes together with aerial mosaics were utilized for the contract plans. Some clearing plans were simple tracings of the preliminary topographic maps with outlined areas of different clearing classifications, such as light, medium, and heavy, surcharged on the tracings as best they could be determined from available aerial photographs and field reconnaissance. It was soon learned that it was less expensive and easier for field appraisal of the work involved when the limits of clearing, usually contours, are surcharged on the aerial mosaics. However, it almost goes without saying that the aerial mosaics taken for preliminary planning purposes a number of yeare before the time of contract bidding were not truly representative of the tree cover during the project construction stages. This necessitated long and careful field reconnoitering by the prospective contractors to make intelligent appraisals and offer firm bid prices.

It is readily appreciated, therefore, that reservoir clearing plans are most useful when up-to-date aerial mosaics and dependable contour information are available for use in their preparation. Cultural features, extent and type of tree cover, and clearing limits are adequately presented on aerial mosaics of a 1:12,000 scale. The most complete and least expensive plans are made when it is possible to use prints of aerial reservoir manuscript maps of a 1:12,000 scale which include both topography and planemetry with the photographic record.

The topographic maps are also used to locate potential mosquito-breeding areas where drainage by ditching will be required, and areas where drift may

be stranded or yarded for removal. The proximity of these areas and other portions of the reservoir to habitation is readily discernible on aerial mosaics. It is on the basis of this information that the reservoir mosquito control and floatage removal plans are formulated. For mosquito control planning the maps should include topography of adjacent areas within about 1 1/2 miles of the line delineating the maximum reservoir operating level on a scale of 1:12,000 and 10-foot contour interval with 5-foot contour intervals between the minimum operating level and maximum flood level where the slope of the terrain is less than 5%.

Reservoir Development and Management

Reservoirs and their fringe lands offer many potential collateral uses which, if not expertly planned in advance of impounding, seldom develop or can be managed for full resource utilization. Congress specifically authorized the Corps of Engineers under direction of the Secretary of the Army to provide and permit others to provide for the development of public park and recreational facilities on government reservoirs when not in conflict with primary project purposes.

The planning for collateral uses is accomplished by preparing a master plan for public-use and recreational development, for conservation and preservation of the resources, and for reservoir management. The master plan considers reservoir area topography, accessibility, relationship to population centers, soil characteristics, vegetative cover, fish and wildlife habitat, significant historical and archeological sites and interests, forestry and agriculture, and grazing land uses. Seldom is this planning achieved without reservoir topographic maps and field reconnaissance.

Planning for development includes the preparation of a general development plan that zones the reservoir area for its many uses, supported by layout plans of individual areas considered suitable and needed for recreational and public-use developments. To finalize the general development plan, site reconnaissance is required; this is greatly aided by having dependable topographic maps and photographic aerial mosaics with which to work. A scale of 1:12,000 for both maps and mosaics is satisfactory for this use although prints of manuscript maps of the same scale containing topography, photography and planemetry would save both time and office work. The layout plans have been mapped on scales varying from 1:8000 to 1:2400, with scales of 1:6000 or 1:4800 being the most commonly used. Contours are needed both below and above the normal operating reservoir water surface to meet the needs for developing swimming beaches, piers, and boat launching ramps in water areas, and for siting buildings, roads, parking areas and utilities on shore lands. A contour interval of 10 feet in steep terrain is adequate but an interval of 5 feet is the maximum needed where ground slopes are 5% or less.

The maps that are used for development planning are of value also for managing and operating the reservoir for recreational and public use, guiding postimpoundment site planning, leasing and facilities construction, marking of boat channels and unsafe areas, and performing fire control, erosion control and mosquito control operations.

Aerial Surveys

Considering that so many reservoir planning purposes may be served by a single aerial survey for reservoir mapping, and recognizing the speed, accuracy and relatively low cost of aerially surveying large areas, apecifications were prepared for securing aerial surveys and stereoscopic mapping of two

major Corps of Engineers reservoir projects in the South Atlantic Division that were either in the design or initial construction stages and contracts were awarded for accomplishment of the work.

The following is a generalized outline of the maps and materials needed for reservoir planning purposes which the contractors were required to furnish for those projects:

a. Aerial photographs of the reservoir area, including negatives, prints and indices.

b. Manuscript sheets covering 3 minuted of latitude and longitude at compilation scale of 1:6000.

c. Planimetric maps of the reservoir area with topography delineated by a 10-foot contour interval, with auxiliary 5-foot contour interval at strategic locations. Also intermediate contours of significant flood pool and operating pool elevations as needed for land acquisition or reservoir clearing.

d. Separate transparent overlay of manuscript sheets showing all vegetation.

e. Two copies of completed maps reduced by photographic process to 1:12,000 scale (one with, one without vegetation).

f. Bound volumes of prints of completed maps reduced by photographic process to 1:12,000 scale.

g. Linen tracings as needed at scale of 1:6000 of special designated portions of the reservoir area.

h. Prints or reproducible films of controlled mosaics at scale of 1:12,000 with and without contours. Also prints as needed of mosaics at 1:24,000 scale.

i. Aerial photographs of river below dam for about 50 miles at scale 1:4800 prepared from low altitude photography.

j. All map compilation materials, including all horizontal and vertical control data, field survey notes, computations, and other pertinent data.

One of these contracts, that of mapping the reservoir area of the Hartwell project on the Savannah River in Ga. and S. C., involved 770 square miles of surveying and mapping and 360 square miles of topography with all work to be completed in 15 months. The other, that of mapping the reservoir area of the Buford project on the Chattahoochee River in Georgia involved 430 square miles of surveying and mapping and 250 square miles of topography with all work to be completed in 10 months. (Sample copies of the aerial maps prepared for the Hartwell project are displayed here and may be examined by those interested following this session.) It is estimated that multipurpose aerial surveying of these reservoir areas executed in accord with the planning described above will reduce overall mapping costs by as much as 60 to 70 percent in comparison with costs that would be entailed were separate surveys made for each purpose as has frequently been done in the past.

CONCLUSION

It is no longer necessary in planning reservoirs to use uncontrolled aerial mosaics combined with topography secured by conventional ground survey methods that seldom furnish adequate maps without inconvenient delays and attendant high costs. During the last decade advances in aerial surveying and photogrammetry have resulted in speedy production of accurate and high quality maps. Concurrently experience gained by engineers in reservoir planning for multipurpose use has shown that the mapping needs for land acquisition, relocations, special reservoir studies, reservoir preparation, and

reservoir development and management can be adequately served by uniform scale maps. With these needs anticipated suitable maps and information can be obtained by aerial surveys and stereoscopic mapping in time to be used for reservoir planning purposes, and at a substantial saving over ground survey and conventional mapping methods.

PROCEEDINGS-SEPARATES

The technical papers published in the past twelve months are presented below. Technical-division sponsorship is indicated by an abbreviation at the end of each Separate Number, the symbols referring to: Air Transport (AT), City Planning (CP), Construction (CO), Engineering Mechanics (EM), Highway (HW), Hydraulics (HY), Irrigation and Drainage (IR), Power (PO), Sanitary Engineering (SA), Soil Mechanics and Foundations (SM), Structural (ST), Surveying and Mapping (SU), and Waterways (WW) divisions. For titles and order coupons, refer to the appropriate issue of "Civil Engineering" or write for a cumulative price list.

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a. Beginning with "Proceedings-Separate No. 200," published in July, 1953, the papers were printed by the photo-offset method.
b. Presented at the Miami Beach (Fla.) Convention of the Society in June, 1953.
c. Presented at the New York (N.Y.) Convention of the Society in October, 1953.
d. Beginning with "Proceedings-Separate No. 290," published in October, 1953, an automatic distribution of papers was inaugurated, as outlined in "Civil Engineering," June, 1953, page 66.
e. Discussion of several papers, grouped by divisions.
f. Presented at the Atlanta (Ga.) Convention of the Society in February, 1954.

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